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Transport interchange and local urban environment integration.

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Abstract

Among the different interchange design aspects, integrated land use and infrastructure planning is maybe one of the most problematic fields in practice, given that a joint transport and urban planning spills over the regular scope of action of interchange developers, whereas it involves the cooperation and agreement of various authorities. Not only this, but the very issue of land use-transport integration seems to be a long-standing mantra in planning and transport research, lacking scientific evidence.
This paper is an output of an ongoing European research project called "NODES - New tOols for Design and OpEration of Urban Transport InterchangeS". Its aim is to start re-focusing the academic-scientific evidence on the question and to foresee a specific and practical framework to approach the problem. The underlying hypothesis is that the interchange could be a catalyst of life and security in the city.

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Keywords: Intermodality; Transport interchange; Interchange design; Urban integration; Urban environment; Land use transport integration.

1. Introduction

The design and management of transport interchange facilities involve a number of key areas such as urban integration, infrastructure design, ICT, management models, energy and environment, that has been partially focused from a practical standpoint in a number of research projects. In fact, most of the references addressing the issue turn to be policy guidelines or design recommendations coming from other European RTD projects, such as INTERCEPT,

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KITE, LINK, MIMIC, PIRATE, SWITCH or GUIDE.

Among the different interchange design aspects, integrated land use and infrastructure planning is maybe one of the most problematic fields in practice, given that a joint transport and urban planning spills over the regular scope of action of interchange developers, whereas it involves the cooperation and agreement of various authorities. Not only this, but the very issue of land use-transport integration seems to be a long-standing mantra in planning and transport research, lacking scientific evidence.

This paper is an output of an ongoing European research project called "NODES - New tOols for Design and OpEration of Urban Transport InterchangeS". Its aim is to start re-focusing the academic-scientific evidence on the question and to foresee a practical framework to approach the problem. The hypothesis is that the interchange could be a catalyst of life and security in the city. In this sense, some vectors and tools are identified, such as the ways to measure density or building typology, the integration of the interchange in the urban network of streets and public space (Space Syntax) and also the importance of the visibility in the surrounding area (isovist analysis) and, finally, the placement of additional equipments and utilities to be taken into account (park&ride, bycicles, offices, etc.). In short, the objective of the paper is to produce a simple but specific framework that may articulate crucial points of agreement on the task of the integrated planning.

2. Background: the interface of interchange and urban environment.

The approach to the concept of Interchange taken herein is a wide one: as it was stated in the document *Towards Passenger Intermodality in the EU* (2004), *"intermodality is a policy and planning principle that aimss to provide a passenger using different modes of transport in a combined trip chain with a seamless journey".* Thus, intermodality is crucial for the integration of multiple modes into one efficient system. But the co-presence of multiple modes –even at the same building– is not enough for an interchange: an intermodality approach should focus on transfers easiness and should aim at a seamless trip. This also yields a sharp distinction between interchange and station. While stations are basically about access and dispersal to a transport system, interchanges involve inter-connection of different transport systems.

In this sense, this paper is focused not on those functions of the interchange that take place within it (connection between underground railway, metro lines, underground bus stations, etc), *but mainly on those taking advantage of the surrounding urban area* (figure 1). These include access or dispersal through different modes (pedestrian, cycling, private vehicle, taxi, etc) as well as in-out links, such as those with local bus or tram stops around the interchange.

Already some authors such as Bertolini (2006) have underlined the importance of the surrounding urban area, for the success of interchange facilities. The variety and complexity of elements to be integrated and considerations that have to be taken in account at this scale, can be easily seen in table 1.

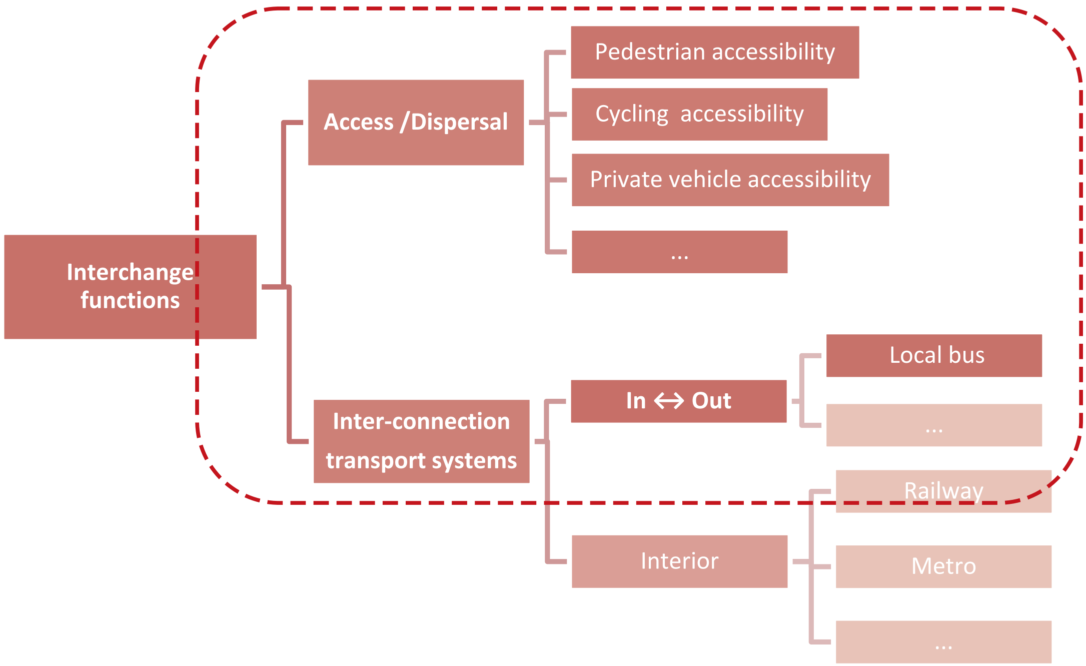

Figure 1: Interchange functions and urban environment.

Table 1: Interchange as an urban space. Bertolini (2006)

Goals	Tips
1. Multiple uses, both in terms of activities and flows.	➔ Locate stations as close as possible to existing/new urban facilities and museums,
2. Plentiful opportunities of interaction between life inside and outside buildings.	Ex: the opening of a direct entrance to a major attraction, connection of stations and public squares or waterfronts, …
3. High visibility and presence of people at all times.	➔ Treat the station and the surroundings as one single public space (visual+physical connections, but also in terms of details and materials).
4. Enough legible points of access to and exchange between different foci of activity.	➔ Bring metro entrances as close as possible to the main local existing activity centre (even when it means extra-tunneling), Treat the inside of the interchange as a public space in its own right.
5. An internal structure favoring the overlap of mobility flows in space and time.	➔ Provide plentiful opportunities for the overlap of mobility flows: more targeted flows, accessing the metro system below ground or the urban facilities above ground + more casual flows, including passers-by.
6. Links with the wider surroundings.	➔ Connect pedestrian channels in the station and pedestrian channels in the neighborhood.

Despite inspiring and useful as they could be, a more systematic approach is clearly needed in such a task. How are transport and the urban environment associated? How can both realities interact strategically in search of the best possible synergies?

Most of the approaches so far have been mostly intentional and based in principles such as the concentration of higher densities or the stimulation of mix-use around stations. Some examples are “MIMIC - Mobility, intermodality and interchanges (1999), PIRATE - Promoting Interchange Rationale, Accessibility and Transfer Efficiency (1999), SWITCH - Sustainable workable intermodal transport choices (2000) or, more recently, K2020 strategy: The ideal interchange – focus on the traveller" (2008)[†]. However and as stated before, the analysis of the relationship transport interchanges-urban environment is an open research field, with limited specific literature and scarce empirical evidence.

Thus, in order to get a wider picture, it is worth to review in the first place the discussion on the requisites of the environment for the different transport modes. Then we will briefly refer to the specific literature on the influence of urban environment for transport interchanges, in order to get specific criteria to build the NODES design tools.

2.1. Built environment and transport studies.

The interest of studying the built environment of transport interchanges is three folded: a) as an influence area, place of the origin/destinations (land uses); b) as a set of channels for the access and dispersal (networks); and c) as the space of the direct interface, the immediate surrounding space between the interchange and its urban environment where in-out inter-connections take place (space).

What variables have been claimed to better explain transport-urban environment relationships? A first approach can be done through the Cervero and Kockelman's well-known 3 D's: Density, Diversity and Design (1997):

- Density ('interests per unit area') has been always defended as a major factor for transport use. The principle is easy: the more built surface is likely to host the more potential trip origins/destinations. Density is studied from the very origin of Urban planning as a disciplinary field. Cerdá or Unwin use it as an elementary variable describing urban environments. Later, density has represented a necessary condition for urban vitality (Jacobs, 1961) and a prerequisite for sustainable urbanization and economic.

- Diversity ("proportion of different land uses in a given area"), it is also known as land-use mix, or mix-use index. Again, some of the classical authors in urban planning (Jacobs, 1961) regarded land-use mix as an effective driver for urban vitality. According to others, when related to compactness in various scales, it means the proximity of living, working and amenities, the mix of compatible functions and the promotion of green modes of transport. Other studies point at more diverse social groups; more equal opportunities (access to amenities and job opportunities); more attractive places to live; more economic vitality of commercial centres; increased safety; more affordable houses in town centres; and optimum use of infrastructures.

- Design ("street network characteristics in the area"). Although also mentioned in Jacobs (1961), namely as the importance of small urban blocks for urban vitality, it has a more difficult definition and a more ambiguous relationship to travel behavior than the first two. Its description has evolved recently, with the aid of GIS systems and other models. Proposed indicators are block size, proportion of four-way intersections or number of intersections per square mile. Other indicators are sidewalk coverage, pedestrian crossings, the presence of trees, block area, intersection density, "cul de sac" density, route directness, major road crossing, railway crossing, etc. These indicators are related to the importance of having a pedestrian friendly infrastructure.

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† http://www.transport-research.info [Last visited: 18th july, 2014]

Main criticism to 3Ds proposal is that the evidence about their effects is still weak, especially when considered separately. Ewing and Cervero (2001) present the state of the question in their ambitious meta-analysis of empirical studies to date.

In the case of density, these authors argue that density all alone show, according to the empirical studies they review, the weakest association to travel choices. These weak relationships indicate that density is an intermediate of other variables, such as accessibility to destinations. Therefore, density might have been used as an unconscious 'proxy' so far. Ewing and Cervero propose to reformulate this factor as accessibility to destinations. In this way, while considering the existence of a number of interest or attractions in an area, what is measured is the ease of access. It seems to explain much better the importance of density and it is usually calculated as the number of jobs, shops, amenities, etc., reachable within a given travel time.

Referred to land-use mix, an obvious criticism is the ambiguity of the term coming from its "all purpose remedy" character. Ewing and Cervero conclude that, actually, jobs-housing balances are stronger predictors of walk mode choice than land use mix measures (i.e. entropy measures). "Linking where people live and work allows more to commute by foot, and this appears to shape mode choice more than sprinkling multiple land uses around a neighborhood".

Any effect is likely to be collective one involving multiple design features. It also may be an interactive effect with other D variables. This is the idea behind composite measures such as Portland's urban design factor, which is a function of intersection density, residential density and employment density.

Another criticism is not to the three factors considered individually but as again, Ewing and Cervero (2001) have put it, planners have advanced though "glimpses of many trees rather than a panoramic view of this complex and rich forest of research". They claim that no built environment variable has an actual important effect on travel by itself but, on the other hand, 'the combined effect of several variables on travel could be quite large'.

Considering this, a number of methods for integrating various spatial analysis methods into one model have been proposed. By combining street network and land use measurement into one map, the spatial potentials for neighborhood centers and the degree of vitality of main routes could be evaluated simultaneously.

2.2. Built environment and interchange facility.

Ewing and Cervero's study (2001) provides quite an interesting insight. They evaluate what kind of built environment factors has the highest influence on each transport mode demand (table 2).

Table 2 : The influence of Built environment factors on transport (after Ewing and Cervero, 2001)

Travel mode	1st factor	2nd factor	3rd factor
Private vehicle trips	Accessibility to destinations.	Street network design	
Walking	Street network design	Land use density	Accessibility to destinations (diversity)
Public transport	Proximity to transport	Street network design	Land use density.

However, it is thought that the table does not show the qualitative differences among the key drivers for the three transport modes. While it is true that walking is highly dependent on, precisely, the already discussed urban environment factors (Street network design, Land use Density and Diversity - accessibility to destinations), in the case of motor traffic, this dependence is minor. In other words, although they use the same categories for both transport modes, we think it is good to make more precise distinctions. For example, in the case of motor traffic, Accessibility to destinations, should probably point out the concentration of land uses, which supports the gravity principle of the traffic models. It could also include traffic conditions, levels of service, etc., which refer to a different type of accessibility, which is variable and depending on time. Or, what it is termed as Street network design should include also design speeds, traffic regulation, etc.

Table 3: The influence of Built environment factors on transport (after Lamíquiz, Carpio-Pinedo&García-Pastor)

Travel mode	1st factor	2nd factor	3rd factor
Private vehicle trips	Access time / “Magnet” character	Traffic regulation	
Walking	Street network design	Land use density	Accessibility to destinations (diversity)
Public transport	Proximity to transport	Street network configuration, access & visibility	

Similarly in the case of the object of this paper, public transport, Ewing and Cervero had added, probably not by chance, a new on purpose new factor: proximity or Distance to transport (average of the shortest street routes from the residences to the nearest rail station or bus stop). Of course, this relates to density and land use mix use: the denser is the transport station environment, the shorter distance to transport is, the bigger mix of activities that need public transport service, the higher interaction potential. These are the principles that guides many land use-transport integration policies, such as the ABC policy in the Netherlands or the Transit Oriented Developments (TOD) in the USA. As a variable, it is a key-factor to understand travel choice of public transport, as it has been proved in many of the studies reviewed by these authors. This phenomenon actually follows a distance weighted decay function (Gutiérrez et al., 2011)

3. Discussion: the role of street network configuration and visibility in the design of transport interchanges

The importance of the “syntax” of the street network for pedestrian movement has been highlighted by “Space Syntax” research since Hillier&Hanson (1984). They argue that not only distance from surrounding land uses has to be considered to understand how stations are reached in the access and dispersal paths, but also the “syntax” or “configuration” of the street network leading to it. In fact, this is a different kind of accessibility based on the form and connectivity of the street network, called configuration accessibility. This is a less know approach in transport studies, so it probably deserves a short introduction. Since the 1980’s, some theories of urban planning, built upon configurational analyses, have tried to understand the role of spatial networks in shaping patterns of both social and economic dynamics. In particular, Space Syntax studies (Hillier&Hanson, 1984) investigate relationships between spatial layout and a range of social, economic and environmental phenomena through the “configurational accessibility” of the street network. Configuration, according to Hillier (1996), is the degree of relationships that a spatial system allows among its elements. Although Space Syntax has the only input data of the accessibility of street network, there is already strong evidence showing its influence on the distribution of the patterns of movement in street networks. In this way, through what they call "natural movement", these studies argue the relationship of this configurational accessibility with diverse phenomena, such as land use density, land use mix and land value, urban growth, safety and crime distribution (Hillier, 1996). How can be this? According to this theory, some land uses, those dependent on the movement of people, naturally seek their best place within the city, and not the opposite. Consequently, this type of land uses (present and future) may be analyzed from the spatial layout.

Based on this logic, Space Syntax studies have developed several modelling tools for urban planning and design, in order to "create the right places (in fact, the right set of potential relationships) to host specific land uses. They include models based in "axial lines" and, also other based on the visibility fields. The later are known as Visual Graphic Analysis (VGA), and analyze spaces as a continue surface ('raster'): the extent to which a location is seen from any other location, or, when they are not directly visible, the complexity implied in getting to see it.

Both kinds of tools are potentially interesting for understanding interchanges, since they provide objective criteria to appraise the urban integration of the interchange and its accessibility. The first one, Space Syntax axial model, allow to measure to what extent transport interchanges are located in a 'strategic positions' within the transport network and integrated in the urban environment. The second one, VGA, is useful to understand how surrounding accessibility of the interchange, both in visual and physical terms.

The last aspect has been less considered in the interchange literature, but it yields a number of problems that interchange design have to tackle, as it can be seen in the following schemes. Visual directness, crossing, the provision of rest facilities, amenities, etc, offers a design problem that has been frequently obliterated, still is an interesting field to work on.

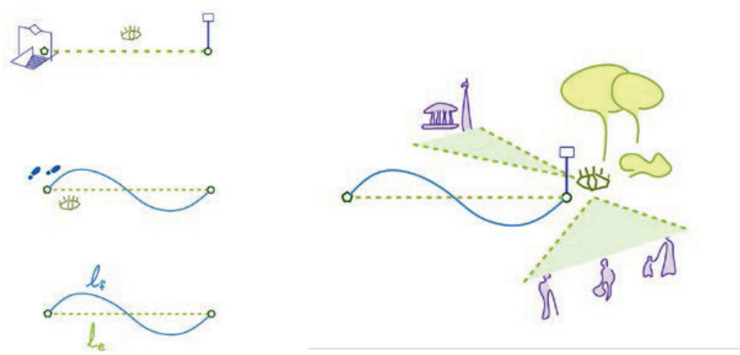

Figure 2: Transport and transfer within open urban area.

Models such as VGA offer objective criteria to analyze these links.

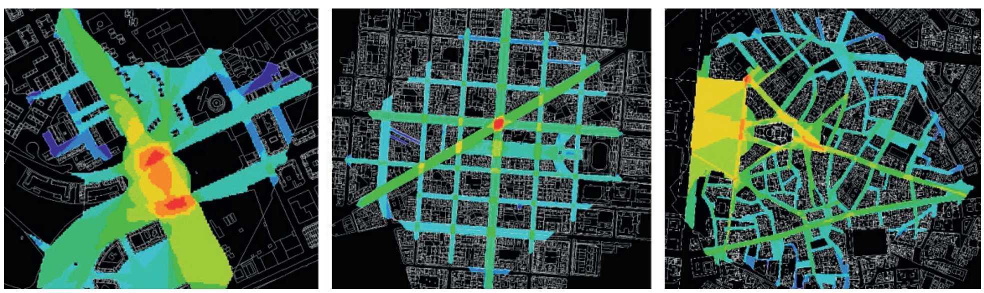

Figure 3: Visual Graphic analysis (VGA) _ Visual integration in three interchange urban areas in Madrid.

4. Conclusion: city – urban environment – public space – interchange.

Paper's review has focused and adapted the particular case of the transport interchange, since most of the literature had focused on the generic case of either land use – transport relationship or standard transport stations and on how to increase access-dispersal (demand) as the one of its main goals. Still, the interchange urban integration issue has to be framed in the wider transport and urban context. Three urban/architectural scales/elements have been considered herein: the "foreland" or the city itself, the "hinterland" or the surrounding urban environment, the public space around the building/area, and the building/area itself. According to these, the paper proposes to consider interchange facilities in three dimensions:

- as a mobility hub (intermodality)
- as a station (access/dispersal)
- as a part of the public realm (staying-urbanity)

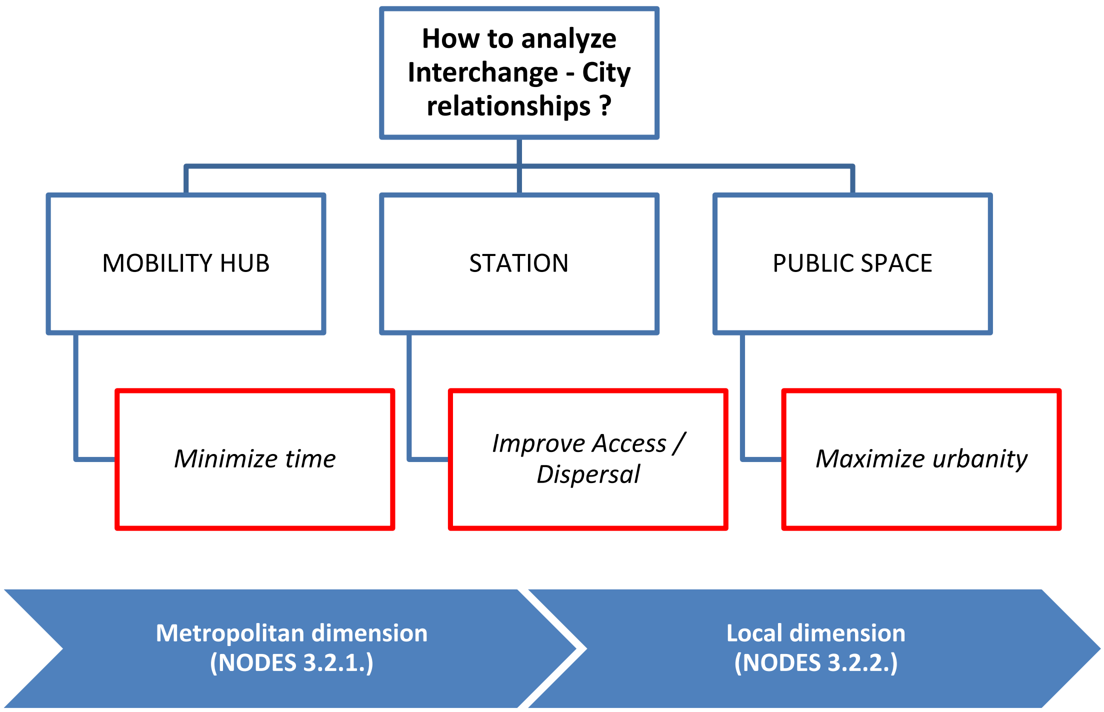

Figure 4 : Interchange - City relationships.

It is interesting to note that, in this way, the aims for the interchange become wider and more complex. Interchanges will be not only about minimizing interchange time (hub), but also about improving access and dispersal (station) and, especially in the case of interchanges, about creating urbanity (public space), creating places. Of course, this makes interchange design a more complex problem, since the three goals can be contradictory to each other: is it possible to minimize interchange time and making a memorable public space at the same time?

This paper analysis suggests the convenience of using configurational and visibility analysis tools in order to increase safety and urban liveability around transport interchanges, in other words, to act a catalyst of urban life in cities. Finally, the proposal focuses on the aspects that are more easily under the control of planners and designers, such as land use regulation and physical-spatial configurations. There are other urban features that are relevant, such as socio-demographic aspects but those were outside the scope of the proposed approach.

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